Numerical Simulation of Sloshing Flows of Liquid Tanks in Waves

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ABSTRACT

The exploitation and the transportation of liquid natural gas energy is very challenging and dangerous in Ocean Engineering. In order to solve these problems, a new type of offshore unit FLNG (floating liquefied natural gas vessel) has been proposed. Among many problems that threatening the survival performance of FLNG, the liquid sloshing problem caused by partially filled LNG tanks has a significant coupling influence on FLNG motion.

Different from the potential flow method in previous researches, computational fluid dynamics (CFD) method has its unique advantages, such as the consideration of fluid viscosity and the strong nonlinear phenomena. Using our in-house unsteady RANS solver, naoe-FOAM-SJTU, which is developed and based on the open source tool libraries of OpenFOAM, the sloshing coupled effect of a floating box which equipped with liquid tanks is simulated in numerical wave conditions in this paper.

Firstly, the motions of the floating box with empty tanks in waves are simulated, the accuracy and effectiveness of the solver are validated by comparing its results with experiment results. Next, to clarify the sloshing influence on ship motion, several tank filling ratios (24.3%, 38.3%, 61.3%) are considered under the same incident wave frequency. The time histories of the corresponding motions are given and discussed, and the influence of the sloshing resonance frequency on sloshing phenomena is revealed and studied. Meanwhile, naoe-FOAM-SJTU solver can also calculate the moments on inside wall and outside wall of the liquid tank, so the coupling influence on the structure motion caused by sloshing and wave force can be studied individually. It is noticed that the amplitude of the rolling motion of the liquid tank has an obvious connection with the phase differences between sloshing moment and wave moment. All above results agree well with the experimental results, which shows that the naoe-FOAM-SJTU solver can effectively simulate the sloshing-motion coupling problem under the wave environment. Besides, on the basis of this study, further researches about other sloshing factors can be carried out in the future.

Keywords: sloshing; Coupling effect; naoe-FOAM-SJTU solver; liquid tank